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GENESIS OF SCIENCE

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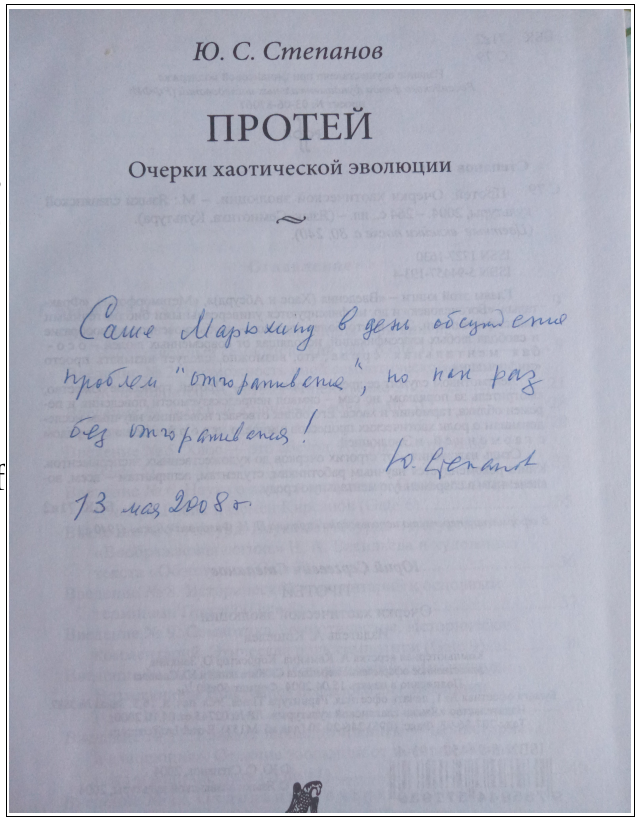
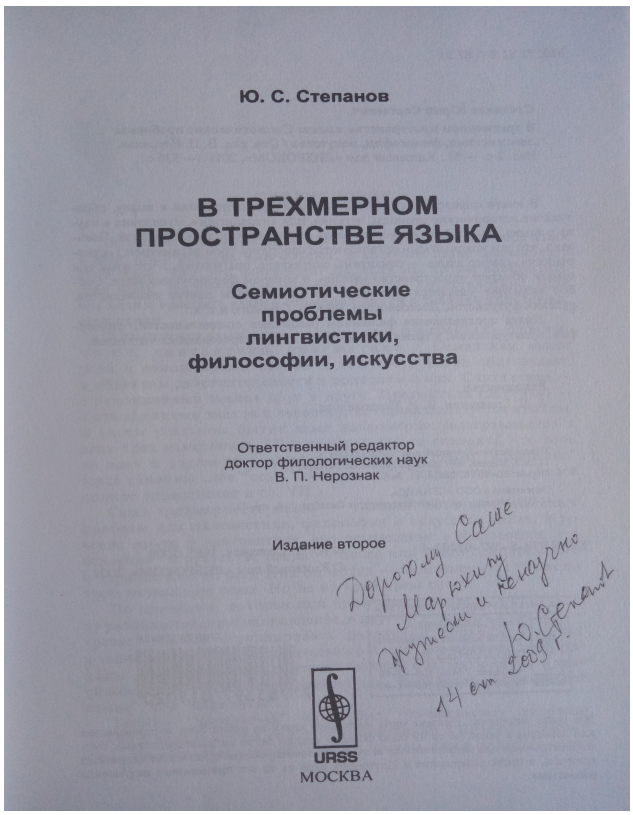
Preface

This volume is devoted to the history of science, to its starting point when etymology of each separated branch was pure and direct.

I remember my acquaintance with Prof. Stepanov in his cabinet and his contribution made towards me. He represented a new book “Concepts”. On its title page he has written the following: “To Alexandr Maryukhin, I shake a hand for scientific future!”



On his other book “Proteus. Essays on Chaotic Evolution” Prof. Stepanov has written “To Sasha Maryukhin on the day of discussion about “linguistic hedging” but yet without “hedging”!
It means that he prepared me to be positive and absolutely open to new challenges of science. Later we concerned “hedging” beyond linguistics in a wide area of philosophy of science.



The same positive and friendly attitude he expressed towards me in his book “In the Three-Dimensional Area of Language”: “To dear Sasha Maryukhin, friendly and unscientifically”.

All these notations helped me to organize this volume. Many forgotten names come to light and life once again.

Astrakhan, 2023

§1. Creativity and Science

"Creativity" as a term for human abilities derives its metaphorical use from the Renaissance: the rediscovery of the artistic ego its personality, the revived ideal of the Greek artist, which became the model for this discovery, as well as the secular and pagan currents of the time, were probably responsible for the fact that a word from the ritual area of theological vocabulary got an aesthetic definition. A quality that could previously be attributed only to God was transferred to humans; in analogy to the "Deus creator" the term "homo creator" came to light. The artist is also a creator, with the only difference that this creation is improperly a creation from nothing, while the "creatio ex nihilo" can only be prescribed to God.

The term remained in such a use until the 18th century. In the 19th century, it was limited to its aesthetic role. Depending on the constellation of intellectual history, it served as a magic word in the cult of genius, as a fashionable word to describe every human achievement, or as an embarrassing term for artistic difference; it could also be expanded into a great philosophical-poetic metaphor that could be applied to every living organism: nature, the individual and the people, language.

With the beginning of the systematization of science in the 19th century, the term "creativity" found its way into a theoretical vocabulary. It was primarily early psychology that, starting with the attempt to define the phenomenon of artistic personality, dealt with "creativity". In order to be able to measure it scientifically, psychology postulated a normal behavior of people, from which it attempted to define creative behavior using criteria such as "deviant behavior", "originality", "elegance", etc. Partly due to the conceptual vagueness of the term "creativity" itself, as well as the difficulty of finding suitable measurement methods for the criteria, this branch of personal psychology soon fell behind its approaches, and the term is still a rather vague construct that has not found a firm theoretical localization. Instead of asking for a general definition, contemporary research is satisfied with the statement that "creativity is not a theoretical construct at all, but a general rubric, under which fall a variety of evaluative concepts".

This lack of conceptual agreement is already evident, for example, in everyday use of the word, which has three different interpretations of "creativity", although the basic criterion of "originality" is common to all: (1) it can designate a latent property of a subject, his/her ability to create something new ("creative personality", "creative atmosphere" etc.); (2) "creative" can also be the attribute given to the process by which something new is created (e.g. in expressions such as "being creative", "acting in the theater is a creative act" etc.); (3) finally, a third meaning can be found by assigning "creativity" to the product of ability and act ("a creative achievement", "a creative work"). However, as mentioned, what all these interpretations have in common is the reference point from which they can be measured: this is always a normal behavior, a normal situation, or the neutral product of both. In other words, "creativity" is defined as the distance that an action or a person takes from a standardized, indistinctive normal situation. When one switches from this

psychological – and also aesthetic – approach directly to Chomsky's use of “creativity”, he/she is faced with completely different sets of facts.

Mr Chomsky interprets “creativity” as follows: “It is the central fact with which any significant linguistic theory must grapple: a mature speaker can, at the right moment, produce a sentence in his/her language, and other speakers will understand it instantly, although the sentence is equally new to them. Most of our linguistic experience, as speakers and as hearers, concerns new statements; once we have mastered a language, the class of sentences with which we can handle fluently without difficulty and without hesitation is so large that it may be considered practically infinite. Ordinary mastery of language, however, means not only the ability to understand an infinite number of entirely new sentences immediately, but also the ability to identify deviating sentences as such and to assign an interpretation to them. This “creative” aspect of language is its essential characteristic”.

Mr Chomsky defines as “creative” a human behavior that is so familiar and trivial in everyday life that one is rarely even aware of its use. The definition of “creativity” as given by behavioral psychology and aesthetics above does not seem to apply to Chomsky's characterization in any case. This is because it compares creative behavior with normal human behavior, and the distance between these two behaviors is qualified as “creative”. A behavior such as human speech cannot be considered “creative” *per se* in such a definition, since it must always yield a value of zero for the criterion of creativity – the measurement of “deviant behavior”. There are now two further possible ways to get closer to Chomsky's concept: either to explain the definition variables psychologically or understand the concept in Chomsky's writings hermeneutically.

The first possibility would arise if one were to change the concept of “normal behavior”. This has actually been done in psychology itself. In the 1930s, a branch of behavioral psychology split off from the previous direction. This was a reaction to the prevailing tendency, which, in view of the required scientific criteria of strict observability and quantifiability, was soon only able to measure “creativity” using the criterion of intelligence and thus increasingly missed the actual research goal. This movement within psychology developed in America and soon became known as “creative” psychology. It attempted to define “creativity” in the normal behavior of living beings in general. “Creativity” was therefore no longer measured exclusively within the human race, and the result of this was that any human behavior could be called creative in itself: the term thus became a species-specific criterion that is genetically determined and which, consequently, was no longer expressed in the artist, but only as a gradual expression of a general human condition.

“Creativity” was thus understood as a dynamic element of the complex structure of humans, which distinguishes them from animals, and which can manifest itself in a variety of forms: for example, in the personal development of children, where creative elements can represent a counterbalance to socialization and the social role formation by society, which are present in both humans and animals and are therefore not species-specific. Criteria for this creativity are sought primarily in play, in the

ability to solve problems, in the reception of the environment and in language behaviour; artistic creativity is only a complicated product of this basis and specific social and cultural influences.

§2. Mathematics and its Disciplines

The name “mathematics” is of Greek origin; the Greeks call it *ἡμαθηματαική*. The stem *μαθ-*, which appears in the word *ἔμαθον* “learned”, “the science” indicates a “striving thought”. Even in Plato's time, *μαθήματα* indicated “learning objects” or “sciences”, everything that was the subject of scientific instruction. It was only by the Peripatetics that the general term *μαθήματα* got a special importance in the mathematical sciences, among the art of arithmetic and a simple arithmetic, the plane geometry and stereometry, astronomy and music.

Almost at the same time, the name “philosophy”, which had previously had the literal meaning of “love of science”, of “the desire for knowledge” or “research”, was given to a special science, the science of knowledge. Plato elevated mathematics to the status of a true science: “Science is not to be pursued for practical purposes, but only for knowledge”. In his Politeia, he explains the difference between philosophy and mathematics by saying that philosophy, starting from a hypothesis, goes back to a primary principle which is no longer based on a hypothesis and carries out its research only with pure concepts, without the help of images such as those used by mathematics.

Pythagorean mathematics had already its own system. Four mathematical disciplines answered the questions posed by the Pythagoreans: “How much?” and “How big?”. Arithmetic dealt with multiplicity in itself, music with multiplicity in relation to other things, geometry with stationary magnitudes, and spherics with moving magnitudes. Plato distinguishes between 5 mathematical disciplines, the study of which he demands as a preparatory school for rational knowledge: 1) arithmetic, which should not be used for everyday purposes, but aims at a conceptual understanding of the nature of numbers, 2) geometry, i.e. only the plane geometry, 3) stereometry, the science of the extension of cubes and of everything that has depth, 4) astronomy, which deals with the physical in its movement, and 5) harmonics, which investigates the movement that reveals itself in harmonious tones. Later mathematicians no longer separated stereometry from geometry, which was borrowed from the Pythagorean school.

At the time of Aristotle (384-322), investigations in the propagation of light, and the laws of equilibrium were added, and the system of mathematics was now made up of the following 6 disciplines: arithmetic and geometry, music and astronomy, optics and mechanics. Essentially, the difference was between arithmetic and logistics in that the former was the study of the properties of numbers in and of themselves, i.e. number theory in the modern sense, while logistics dealt with the formation of numbers in relation to sensible objects, i.e. was the practical art of calculation. The

music, *κανονική*, the doctrine of harmony in the broadest sense of the word, took its name from the *κανών*, "the scale of the monochord", which Pythagoras and others used to determine the laws of tones.

Geminus divided all mathematics into two main parts. The first, which deals with the intelligible, the mentally perceptible, contains arithmetic and geometry; the second, which develops its activity on the sensible, the sensually perceptible, contains mechanics, astronomy, optics, geodesy, music and logistics. The ancients did not go beyond this division.

Several mathematical disciplines mentioned above belonged to the "liberal arts", (*τέχναι*, *artes liberales*), whose concept developed among the Greeks and which extended into the Middle Ages. Marcus Terentius Varro (probably 116-27 BC), the most learned man of his time, wrote an encyclopedia in nine books: "De Disciplinis", which served as a model for later encyclopedists such as Martianus Capella, Cassiodorus, Isidorus Hispalensis and others. The order of the nine sciences treated in this unfortunately lost work was as follows: grammar, dialectic, rhetoric, geometry, arithmetic, astrology, music, medicine, architecture.

Later, towards the end of the 5th century, the Latin world knew seven "liberal arts", the Trivium: grammar, rhetoric, dialectic, and the Quadruvium: arithmetic, geometry, music, astronomy. The former indicates the threefold path (*triplex via*) leading to eloquence. The word "quadruvium" (literally a crossroads into which four roads lead), which is used for the four mathematical disciplines, is initially found in Boethius. Using a similar model, Cassiodorus speaks of the mathematical disciplines mentioned as the 4 postulates of Mathesis (*quadrifariae mathesis januae*).

The Arabs added common arithmetic, lower algebra and trigonometry to what they had learned from the Greeks and the Indians. Their learning was transplanted to Europe at the beginning of the 13th century, and by the end of the 16th century the science of the European civilised peoples had taken on the character of the Indian and Arabic. The first area in which they developed their own activity was algebra. Here we first find the analytical approach peculiar to modern sciences. Their method reveals the particular from the general, in contrast to the synthetic geometry of the ancients. Descartes made this approach to algebra usable for geometry as well; he created analytical geometry and thereby became the founder of modern mathematics.

If the concept of geometric magnitude was to be merged with that of discrete number, the contradiction in the comparison of continuous magnitude with numbers had to be eliminated, and this was done through the idea of the infinitesimals. Leibniz and Newton can be called the creators of the infinitesimal calculus. In this way the science of analysis arose and built the theory of the relationships of constantly changing quantities on the concept of function. Finally, at the beginning of this century, synthetic or projective geometry joined analytical geometry.

It would take us too far here to even briefly outline the content of all the branches into which the mathematical disciplines just mentioned have been divided up to now. We will only mention a few things concerning the system. Pure mathematics is separated from applied mathematics and the difference can be

formulated as follows: pure mathematics examines units of numbers and units of magnitude in and of themselves, applied mathematics examines them with the aim of discovering relationships between objects of reality which are imagined under the image of number and magnitude. The necessary relationships which flow from the nature of numbers are the subject of arithmetic in the broader sense; those which result from the nature of space are the subject of geometry. Arithmetic in the narrower sense is concerned with the development of the concept of number. The task of algebra is to determine properties of unknown numbers which result from their relationships to known numbers. Finally, analysis deals with variable quantities. Applied mathematics includes mechanics, mathematical physics and astronomy; its object is the world of sensory perception, its content is the doctrine of movement.

As for the names of our disciplines, we have already mentioned, the difference between arithmetic and logistics is to be given. In the Middle Ages, the word "logistics" lost its original meaning; some understood the term "logistica" to mean the study of elementary algebraic operations, others – the solution of equations. Vieta applied the term "specialized logistics" in his *Artem Analyticam* in 1591. The addition *speciosa* was justified by the fact that numbers were represented by shapes, images, figures. The Italian mathematicians of the Middle Ages distinguished the *logistics numerosa*, calculating with numbers, from the *logistics* (or arithmetica) *speciosa*, the letter calculation. The name "arithmetic universalis" was introduced by Newton for algebra, the study of equations. He calls it *universalis* presumably because it can often be used to solve geometric problems. The science of numbers which Gauss called *arithmetic sublimior*, higher arithmetic, *Legendary theory of numbers*, was number theory; its elements deal with what one could with some regret call "the chemistry of numbers".

The task of geometry corresponded to its name *γεωμετρία* from *γῆ*, "Earth", and *μετρεῖν*, "measure", comes very little to the concept of this science, even if one wanted to replace the Earth, the part of space that is initially accessible to us, with space in general. Between geometry and geodesy, *γεωδαισία* (from *γῆ*, "Earth" , and *δαίομαι*, "parts"), there was a similar difference, at least in the time of Aristotle, as well as between arithmetic and logistics. However, the definitions of geodesy have varied greatly. In more recent times, for about two centuries, the main task of geodesy has been seen as determining the true shape of the Earth.

The name "algebra" has a peculiar origin. Muhammed ben Mûsâ al Hovarezmi wrote a work around the year 820 under the title "Al mukabala", which was highly valued in its time and had a great influence on the development of Western mathematics. The expression in the title refer to the two simplest operations that can be carried out with an equation or more correctly in the sense of the Arabs and the old Italians, for whom the form of an equation reduced to zero was an absurdity, with an equality of two absolutely positive quantities.

In India, algebra is called *vija-ganita* or *vija-kriya*, actually original calculation or original operation, causal calculation, insofar as the algebraic operation, in contrast to the usual numerical calculation simultaneously reveals the reasons for the

procedure. Another name for our science was *avyakta-gaṇita* or *avyakta-kriya*, calculation or operation with the unknown (*avyakta*). In contrast, common arithmetic is sometimes called *vyakta-gaṇita*, that is, calculation with known quantities. In these names, as in most of the Indian technical terms, there is also the definition of the term.

§3. Arithmetics

The origin of numerals certainly dates back to the earliest period of human language formation; the great similarity of numerals alone provides evidence of ancient ancestral relationships between peoples. Experts are not unanimous about the original meaning of numerals. Many have tried in vain to discover verbal roots in numerals. In the numerals of some uncivilized peoples, we find names for concrete quantities of things; in general, however, numbers are purely abstract. Only a few numbers required a special name, since the way in which one number was created from another was recognized early. The Persian word *pendj* = 5 is derived from Persian *pencha*, "the fist". From the same root comes the Sanskrit word *pancha*, 5, Gr. *πέντε*, Lat. *quinque*, Goth. *finf.* With the progression from mere counting to linking numbers and calculating, number systems emerged.

These are formed according to the same principle by all peoples who have such a number system. The decimal number system, according to which all civilized peoples count, was probably formed according to the number of fingers. It has special simple words for the nine ones and for the first powers of the base number 10. The grammatical connection of the two number words, the ones and the corresponding level number, is very different, as the example given by Hankel shows:

18 means in Latin *December and October* (10+8),

French *dix-huit* (10, 8),

German *achtzehn* (8, 10).

For the higher number of levels, words often express an indefinite plurality, for example the Greek *μύριοι*, "actually innumerable", for 10000. In the 2nd book of Pappus, in which the multiplication method of Apollonius is presented, the numbers below 10000 are called "units", the 5-8 "digits, simple myriads", the 9-12 "digits, double myriads", and so on, ordered by powers of 10000 up to the 10000^{13}. Archimedes grouped in his sand calculation, Latin *arenarius*, a grouping of very large numbers by octads, $1\text{-}10^8$, $10^9\text{-}10^{16}$ etc.

The Indians, who are inclined to the fantastic, are the richest in numerals for higher levels of numbers. The word "million", which in Italian originally seems to have referred to a concrete measure, namely 10 tons of gold, probably first appears as an abstract numeral in Pacioli's "Summa de Arithmetica", 1494. The words *billion, trillion, quadrillion, quillion, sixlion, septilion, octilion, nonillion* can be found in the handwritten treatise by Nicolas Chuquet from Lyon, "Le Triparty en la Science des nombres", completed in 1484.

In the earliest times (c. 600-300 BC and later), the Greeks chose the initial letters of the number words to denote numbers; these symbols are called *herodian* after the Byzantine grammarian Herodianus (c. 200 AD), who described them. Later (shortly after 500) two other methods of number designation developed; one represents the numbers 1 to 24 using the 24 letters of the Ionian alphabet, while the other assigns non-sequential numerical values to the individual letters. It is not yet clear whether the Greeks or the Hebrews are the oldest people to use number designations. There is no trace of a symbol for zero among the Greeks; zero was not a number for them.

Calculating with digits is of Indian origin. The Indians initially used digits only for the nine units, 1 to 9; the symbol for zero was added later. In the 8th century, the Arabs of the East became familiar with the digits, which had been later significantly modified. Through the Arabs, these Indian digits came to Europe at the end of the 10th and the beginning of the 11th century. The names for these digits, namely 1 *igin,* 2 *andras,* 3 *ormis,* 4 *arbas,* 5 *quinas,* 6 *calctis (caltis, caletis),* 7 *zenis,* 8 *temenias (zemenias),* 9 *celentis*, in which one has searched in vain for Greek words, are nothing but Arabic words mutilated by oral tradition. These foreign names survived only for a short time. The Indian method of using Gobar numerals became known in Europe in the 12th century; the names were no longer taken into account. Along with the numerals, the Arabs also passed on the designation of zero with *shifr* into the Western languages. *Al Shifr* means “emptiness” and is a translation of the Indian *sunya*.

§4. Chemistry

Chemistry as a science (*scientia chimiae*) is first mentioned by Julius Maternus Firmicus, who wrote in the first half of the 4th century a work on astrology, which has been preserved in a very fragmentary state, and is usually entitled “Mathesis”. What is meant by this science he does not tell us; but another writer, who probably lived at the same time, if not earlier, gives us information. Zosimus of Panopolis states how Georgios Synkellos, in the 9th century, reports that *χημεία* or *χυμεία*, as it is written in some manuscripts, is the art of representing gold and silver; and in the same sense this word is used by other Greek writers.

These were all closely connected with the University of Alexandria, from which it has been concluded that the artificial preparation of the precious metals was first attempted in Egypt. This country was conquered by the Arabs in 640, who thus became acquainted with chemical science, and whose name was given to their article, which now became known as *alchymy* or *alchemy*.

The origin and meaning of these terms have been the subject of much debate. As Plutarch reports, *χημεία* is the ancient name of Egypt, which was so named because of its black soil, and from this it was concluded that chemistry meant the science of Egypt, which has recently been supported by important voices. The same word was also used to describe the black of the eye, the symbol of darkness or mystery, and it

was therefore assumed that chemistry meant the secret science or black art. The latter name was never given to *alchemy*, however, but was used exclusively for magic or necromancy.

Another derivation is from *χυμός*, "juice" or "liquid", against which it has been objected that it was originally written *χημεία* and not *χυμεία*, which, although Kopp leans towards this view, has not been established with certainty. Humboldt believes that the latter form came into the manuscripts through a copying error or as a result of incorrect pronunciation and continues: "Alchemy began with the metals and their oxides, and not with the plant juices". However, this objection cannot be maintained, since in the older alchemical writings plant juices or preparations designated by this name are mentioned as particularly effective metal-transforming agents.

Gildemeister maintains the derivation from *χυμός*; in discussions about the etymology of the word "alchemy". *Kîmiyâ* is not originally an abstract term among the Arabs, but the name of the substance or means by which the transformation of metal is brought about, that is, the philosopher's stone or rather the preparation obtained from it; it is synonymous with *iksîr*, which also means the transforming agent. On the other hand, "alchemy" as a discipline is called the production of *kîmiyâ*, just as it is called the production of *iksîr*, or more briefly, the science of *kîmiyâ*, or the substance by which gold and silver are artificially brought to perfection. The Qamus, the Arabic lexicon, gives no other meaning, the *aliksîr* is explained by *alkîmiyâ*, *and alkîmiyâ* by *aliksîr* and every means applied to a metal to bring it into the sphere of the sun and moon, that is, to transform it into gold or silver.

Pasha of Nicosia spoke a lot with Kotschy about flowers, especially about *kimia*, a plant that is said to have the ability to transform metals into gold. This word was then easily abbreviated to science of the *alkîmiyâ*, and was then used solely for the discipline. The word *aliksîr*, however, was retained as the name for the means of transformation or the philosopher's stone; it is identical with *ξέριον*, which the Alexandrians used to describe the stone. The same word was also used by doctors to describe a remedy that was used to dry wounds.

But if *iksîr* and *kîmiyâ* originally referred to something similar, or at least something that served the same purpose, and the former takes its distinguishing name from a formal property, it is most likely to presuppose a similar reason for the naming of the latter as well, and since the natural correlate of drying is moisture or liquid, one is led to *χυμός* as the basic value; from this *χυμεία* is derived as a material word, like *λιθεία*, stone material, from *λίδος*, or as the occupation with *χυμός*, like *κεραμεία* from *κέραμος*.

Ibn Khaldun, one of the most important Arab historians, who lived in the 14th century, states that after chemical treatment, a powder or liquid called *iksir* is obtained from the stone, which, when thrown onto molten silver, turns this into gold and copper into silver. Contrary to the etymology, the word is therefore used for a liquid preparation, perhaps because of the aforementioned change in the term *kîmiyâ*, and this explains how elixir later came to be used exclusively in the West for liquids. As long as our science only existed as *alchemy*, mineral bodies were naturally

subjected to more investigation than organic substances. However, improvements in distillation led to the discovery of various essential oils and spirits of wine or alcohol, which was considered one of the substances by means of which the philosopher's stone could be prepared. At the same time, it was considered to be an extremely effective remedy, which is why it was called *aqua vitae*, and Raymundus Lullus, who suggested various methods to keep it as strong as possible, said that it made old people young again and was “consolatio ultima corporis humani”.

He also investigated the action of sulphuric acid on alcohol and describes it in his “Epistola accurtationis lapidis”, which he addressed to Robert Bruce, King of Scotland. He also knew of the violent action of nitric acid on alcohol, which is why it was assumed that he knew of ordinary ether and of sweetened nitrous spirit or nitrous ether, which, however, seems very doubtful. The dry distillation of organic substances, such as tartar, was also first attempted at that time.

Until the 16th century, the almost exclusive aim of chemical research was to find the philosopher’s stone. But from then on, our science was divided into two directions which were traced by two great men; Agricola, the father of metallurgy, and Paracelsus, the founder of jatrochemistry or medicinal chemistry. Both contributed greatly to the advancement of inorganic chemistry; jatrochemistry, which one might expect to develop organic chemistry further, precisely because, in opposition to the school of Galen and Avicenna, it used almost exclusively metallic preparations as remedies. Only a few of its followers attempted to extract the active constituents from organic bodies. Thus were discovered benzoic acid, succinic acid, wood vinegar and lactose.

A new chapter in the history of chemistry begins with Robert Boyle, who was the first to state firmly that chemistry must be studied for its own sake as a branch of general natural science, and not to serve alchemical or medical purposes; it must no longer be the handmaiden of the arts and crafts, but must stand independently as a science; only in this way can it develop vigorously.

Boyle was also the first chemist to clearly address the difference between simple bodies and compounds. In his “Sceptical Chemist” he put forward the view that it is not possible to determine the number of the ultimate constituents of bodies with such certainty as it has been done so far. He showed, among other things, that dry distillation does not, as was assumed, break bodies down into their elements, and supported this claim by his observation that wood vinegar, which was considered to be the spiritual principle of wood, contains an acidic body as well as an indifferent one, which can be separated from the latter by distillation over burnt coral. The wood spirit thus discovered he called, in contrast to wood vinegar, *adiaphorous spirit*.

After the difference between elements and compounds had been clearly recognized, it became possible to determine the composition of bodies by synthesis and analysis, although initially only for inorganic substances. At the same time, a sharp distinction was first made between organic and inorganic bodies.

Until then they were grouped according to their physical properties. Olive oil and other fixed oils were combined with oil of vitriol and oil of tartar (melted

potash), as spirit of wine (*spiritus vini*) with tin chloride (*spiritus fumans Libavii*), ammonia (*spiritus cornu cervi*), ammonium sulphide (spiritus fumans Boylei), nitric acid (*spiritus nitri fumans Glauberii*) and hydrochloric acid (*spiritus salis Glauberanus*). Butter was classified with zinc chloride (*butyrum zinci*), antimony chloride (*butyrum antimonii*), arsenic chloride (*butyrum arsenici*) and similar soft chlorides. Colorless bodies that are soluble in water and have a peculiar taste were called *salts* from the time of Pliny, and sugar was therefore considered as such, while the colored salts of heavy metals were called *vitriols*.

In 1675, Lemery published his famous textbook under the title “Cours de Chymie”, which was published in thirteen editions during his lifetime, and in 1756 appeared in a completely revised edition. It was considered the best textbook and was translated into Latin, English, German, Italian and Spanish. According to Lemery, the task of chemistry is to learn about the different substances “which meet in a mixture”, by which he meant natural products in general, which he distinguished as mineral, vegetable and animal. In the first group he included metals, minerals, earths and stones; in the second group he included plants, resins, gums, sponges, fruits, seeds, juices, flowers, mosses, manna and honey; and in the third section he treated animals, their individual parts and their excrements. His classification was therefore based only on the origin of the various substances and was erroneous because it was too strict. Thus, amber and the products of its dry distillation are treated as mineral substances, while he places tartar and other potassium salts among the vegetable substances, while acetic acid, its salts and the products of their dry distillation are listed in the first section. In the third part he speaks only of the distillation of vipers, urine, honey (although he classifies it as a vegetable substance at the beginning of his work), and of the distillation of wax. Lemery's classification initially remained the dominant one, and the founders of the phlogiston theory sought to justify it, which was based only on the origin of chemical substances, from a purely chemical point of view.

As early as 1669, Becher believed in his “Physica subterranea” that the elements are indeed the same in all kingdoms of nature, but that in vegetable and animal substances they are composed in a complicated way, while in mineral substances they are composed in a very simple way. In “Specimen Becherianum”, 1702, Stahl is of the opinion that in vegetable and animal bodies the aqueous and combustible elements predominate. Both appear when these substances are heated in the absence of air or are subjected to dry distillation, whereby water escapes and carbon remains. Stahl's definition of organic chemistry is just as admirable as that of chemistry in general: “Chemia, alias Alchymia et Spagirica est ars corpora cel mixta, vel composita, cel aggregata etiam in principia sua resolvendi, aut ex principiis in talia combinandi”.

In the first textbooks on the phlogistic theory we find the compounds now called *organic* combined with other combustible compounds. Sulphur, the various kinds of coal, earth resins, vegetable resins, vegetable oils, animal fats and camphor form a common group. It was assumed that these contained phlogiston as a closer constituent

in the combination with oil.

Until the end of the age of phlogistic theory, organic chemistry made no particular practical or theoretical progress. The study of organic bodies served pharmaceutical purposes or was aimed at improving technical processes, such as dyeing. But towards the end of the last century organic chemistry began to make more rapid progress as purely scientific investigations were now carried out.

Among the chemists who worked in this direction, Scheele is particularly worthy of mention. He discovered the most important organic acids, or was the first to distinguish them sharply from one another, such as tartaric acid from citric acid; he showed that apples contain a different acid from the two, and that another is found in wood sorrel. The latter he obtained artificially by oxidizing cane sugar with nitric acid, while milk sugar provides a different substance, mucous acid. He also found gallic acid in galls, uric acid in urine, and lactic acid in sour milk. To prepare several of these acids, he first used methods that are still in use today. Before that, only succinic acid and benzoic acid were better known, which are easily obtained by heating amber and benzene. Scheele showed that the latter acid forms a calcium salt that is easily soluble in cold water, while it is itself sparingly soluble in it, which is why it can be easily obtained by boiling benzene with milk of lime, concentrating the filtrate, and then separating the benzoic acid with hydrochloric acid.

Malic acid, tartaric acid and citric acid, on the other hand, form salts insoluble in water with lime or lead oxide, with the help of which they can be separated from other substances found in the fruit. By then decomposing the salts with sulphuric acid, the pure acids are obtained. Scheele also demonstrated that the oils and fats contain a common component, which he called *sweet oil*, which is now known as glycerin. According to him, this is related to sugar not only in its sweet taste, but also in that it is oxidized by nitric acid to oxalic acid.

His friend Bergman also promoted organic chemistry in a similar way, while Rouelle worked on animal chemistry, which had been completely neglected until then, and separated a peculiar crystallizable body from human urine, which was later called *urea*, while in the urine of cows and camels he found a salt similar to benzene flowers, which was later also detected in that of horses and was long thought to be benzene acid, until Liebig showed in 1829 that a new acid was present here, which he called *hippuric acid*.

Such investigations gave a great impetus to the further study of organic bodies, and Lavoisier, having found the correct explanation for the process of combustion, first analyzed some of them. He concluded that vegetable substances consist mostly of carbon, hydrogen, and oxygen, while animal substances contain, in addition to these elements, nitrogen and sometimes phosphorus. His chemistry was essentially that of oxygen and its compounds; consequently, he always first investigated whether a body could be combined with oxygen or whether it already contained this element. He called the part combined with oxygen “la base” or “le radical”. These terms were first used by his friend Guyton de Morveau, who, after having dealt with the acids of nitrogen, carbon, sulphur and phosphorus, introduced the nomenclature of acids of

unknown composition, such as hydrochloric acid, borax acid and acetic acid. Lavoisier extended these views; a radical could be a simple or a compound body, and he therefore says: “Le carbone est le radical de l'acide carbonique”, while in plant acids there is “le radical oxalique tartarique”, etc.

The observation that an element can form different oxides led him to assume that this was also the case with organic radicals, which is why he considered sugar to be the neutral oxide “d'un radical hydro-carboneux” and oxalic acid to be its higher oxidation state. He even went so far as to suggest that fatty oils, which he considered to be hydrocarbons, were organic radicals in the free state and could be converted into neutral oxides and vegetable acids by oxidation.

Among his other researches in the field of organic chemistry, we must mention here his investigation of mental fermentation, not so much because he was the first to correctly recognize that sugar decomposes into carbonic acid and alcohol, but rather because, realizing the importance of this observation, he explained that the weight of a compound undergoing a change, as well as of each element contained in it, must be found in the products of decomposition, and that it is therefore possible to express such a process by an equation, the correctness of which can be checked by analysis of the original compound and its products of decomposition.

Moreover, Lavoisier did not consider organic chemistry as a separate part of science, and still less did he define it as the chemistry of compound radicals, as has been claimed. He grouped all acids together and divided them, like Lemery, into mineral, vegetable, and animal. His immediate successors also used this division, and only exceptionally do we find organic bodies united in a special group, as in Gren's “Outline of Natural Science”, which appeared at the end of the last century and described them as the more detailed components of the vegetable and animal organism, which are composed of only a few elements in various proportions and cannot be artificially produced.

But when it was discovered that different bodies exist simultaneously in the plant and animal kingdoms, and therefore there is no difference between vegetable and animal chemistry, the division into inorganic and organic chemistry became generally accepted.

But until modern times there remained uncertainty and disagreement about the boundary between these two disciplines. One reason was that the compounds from the mineral kingdom, as well as some which had to be considered organic, gave figures when analyzed which proved that the composition of these bodies obeyed the laws of constant and multiple ratios. The majority of organic compounds, however, as Berzelius says in 1811, did not seem to do this, which is why he intended to decide this question by analyzing a larger number. He therefore developed organic analysis further and found that most organic bodies, although they have a much less simple composition than inorganic ones, nevertheless obey the above laws.

Adopting Lavoisier's views, he said: “After having become more familiar with the difference between the products of organic and inorganic nature, and the different ways in which their more distant constituents are combined with one another, we

have found that this difference consists in the fact that in inorganic nature all oxidized bodies have a simple radical, whereas all organic substances consist of oxides with compound radicals. In vegetable substances the radical generally consists of carbon and hydrogen, and in animal substances of carbon, hydrogen and nitrogen".

However, Berzelius did not examine these hypothetical radicals in more detail at the time, although cyanogen, discovered by Gay-Lussac in 1815, was an excellent example of a compound radical. At the time, most chemists considered cyanogen compounds to be inorganic. A dividing line was therefore still missing; Gmelin said in his 1817 handbook of theoretical chemistry that inorganic compounds must be strictly separated from organic ones, but that the difference is better felt than defined. He considered the former to be characteristic of the fact that they are structured in a binary manner; the simplest consist of just two elements, such as basic and acidic oxides, which combine again to form a higher-order binary compound, a salt.

The simplest organic compounds, on the other hand, are ternary or composed of three elements, and in fact are less simple than inorganic ones. He therefore describes swamp gas, oil-forming gas, cyanogen, etc. in the inorganic part. He finds the difference between inorganic and organic compounds in the fact that the former can be artificially constructed from their elements, but the latter cannot.

Another view, which came into force at that time, followed Stahl's view that organic bodies consist of aqueous and combustible elements. Gay-Lussac had found in 1815 that the volume weight of alcohol vapor is equal to the sum of the volume weights of water vapor and oil-forming gas.

In the following year, Robiquet and Colin showed that hydrogen chloride ether could be considered a compound of hydrochloric acid and oleaginous gas. Based on these observations, Dumas and Boullay put forward a theory in 1828 according to which many derivatives of alcohol were considered to be compounds that contain oleaginous gas as a closer component and according to which they could be placed alongside ammonia compounds. The following compilation is taken from their treatise, although the formulas have been translated into today's notation:

Hydrochloric ether	Ammonia hydrochlorate
C_2H_4, HCl	NH_3, HCl
Nitrous ether	Ammonia hyponitrite
C_2H_4, HNO_2	NH_3, HNO_2
Sulphonic acid	Ammonia bisulfate
C_2H_4, H_2SO_4	NH_3, H_2SO_4
Alcohol	Liquid ammonia
C_2H_4, H_2O	NH_3, H_2O
Sulphuric ether	----------
$(C_2H_4)_2$,H_2O	----------

They extended these views not only to other derivatives of wine spirit, but also

to compounds such as sugars, which they compared to the carbonates of ammonia. Berzelius, who initially opposed these views, later took them up again and proposed the name ether for the oil-forming gas. Although this was the first time that a large number of organic compounds were grouped together from a unified point of view, the ether theory did not find general acceptance because it was not possible to extend it to a large number of compounds and there were also various arguments against it. Thus, although it was possible to convert alcohol into ether or oil-forming gas by removing water, neither these nor other ether compounds could be synthesized from their supposed components, which was so easy to do with ammonia compounds.

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